

Habitat selection of Guizhou golden monkey (*Phinopithecus roxellanae brelichi*) in Fanjing Mountain Biosphere Reserve, China

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Abstract: Guizhou golden monkey (*Phinopithecus roxellanae brelichi*) is a peculiar, rare and endangered species. It is distributed most narrowly and requires a rigorous habitat. In this study the habitats of Guizhou Golden Monkey were divided into three habitats: most suitable habitats, suitable habitats and marginally suitable habitats. The characteristics of the vegetation community, environmental factors and extreme environmental factors in the three habitats were systematically analyzed. The seasonal activity rule, activity area and the food characteristic of Guizhou golden monkey were also studied at the same time. The results indicate that the evergreen and deciduous broadleaf mixed forest is the optimal living vegetation community for Guizhou golden Monkey, and the suitable annual temperature is 8-15 °C, the extremely lowest temperature is -2.5 °C, the extremely highest temperature is 25 °C, and the optimal living altitude is 1500-1700 m. In the same area, the higher the vegetation diversity, the more suitable it is for the life of Guizhou golden monkey. Temperature and food are the main habitat factors in determining the activity scope of the guizhou golden monkey community. The Altitude, temperature and the characteristics of the vegetation community are the main limiting factors for habitat selection.

Keywords: Habitat, *Phinopithecus roxellanae brelichi*, Community, Environmental factor, Fanjing Mountain Biosphere Reserve

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Introduction

The biosphere reserve concept, launched by UNESCO's Man and Biosphere Program in 1979, is a protected area of representative environments, internationally recognized for its conservation value and for providing scientific knowledge, skills and human values to support sustainable development (UNESCO 1987). A biosphere reserve normally consists of three components: one or several core zones, a buffer zone, and a transition zone, each with different characteristic conservation roles (Li 1999). In view of the most endemic and endangered animal species, the core zone is the highly suitable habitat, and is strictly protected according to well defined conservation objectives and should be a typical example of natural or minimally disturbed ecosystems (Augustin 1996; Buckland 1993).

The Golden Monkey (*Rhinopithecus*), under the jurisdiction of *Primates*, *Cercopithecidae* (Song 1959), is a first-class protected species in China, and it is one of the most endemic and endangered species in the world (Fig. 1). The Golden Monkey has three subspecies, Guizhou Golden Monkey (*Phinopithecus roxellanae brelichi*), Si-

chuan Golden Monkey (*Phinopithecus roxellanae*) and Yunnan Golden Monkey (*Phinopithecus bieti*) (Li, 1981). The number of Guizhou Golden Monkey is the least and its distribution area is the narrowest. The one and only habitat area for the Guizhou Golden Monkey population is in Fanjing Mountain Biosphere Reserve of China (Xie 1986). The Man and Biosphere (MAB) Program was launched by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 1971 as an intergovernmental large-scale program with multi-disciplinary teams. The Biosphere reserves are areas of representative terrestrial and coastal / marine ecosystems, or a combination thereof, which are internationally recognized within the framework of UNESCO's MAB program (Xu 1986; Zhou 1990). The total number of Guizhou golden monkey's individuals in 1994 was about 800 (Xie 1986). The habitat of this species is the total action of ecological factors on biology in the specially designated area, and it is an idiographic environment of biological individual, population or community (Zhou 1990). Study on habitat of Guizhou Golden monkey is very important for the management and development in the natural reserve. Fanjing Mountain Nature Reserve was set up in 1978, designed to be a national nature reserve in 1986, and was accepted as a member of MAB in 1986 (Chinese National Committee for MAB 1998), meanwhile Fanjing Mountain Nature Reserve bears the research program of Man and Biosphere Program of China. It is one of fourteen Biosphere Reserves in China (Fig. 2). The research history of Fanjing Mountain began in the 1930's,

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and the important research work on the vegetation of Fanjing Mountain was undertaken by Jian Zhuo in the 1960's. The comprehensive research on Fanjing Mountain was carried out in the 1980's. Since 1978 when the reserve was founded, the number of Guizhou golden monkey individuals there increased to about 750 in 1986 and reached about 800 in 1997. The Guizhou golden monkey's main habitat was evergreen broad-leaved and deciduous broad-leaved mixed forest, at an altitude between 1500-1900 m, but intensive exploitation of the forest has destroyed much of the original forest environment. However, protection of the original forestry environment and habitats has been carried out during the course of this development by establishing the Biosphere Reserve. Knowledge of habitat use and selection by Guizhou golden monkey can help develop management strategies for this endangered species.



Fig.1 Guizhou golden monkey (*Phinopithecus roxellanae brelichi*) in the Fanjing Mountain Biosphere Reserve of China

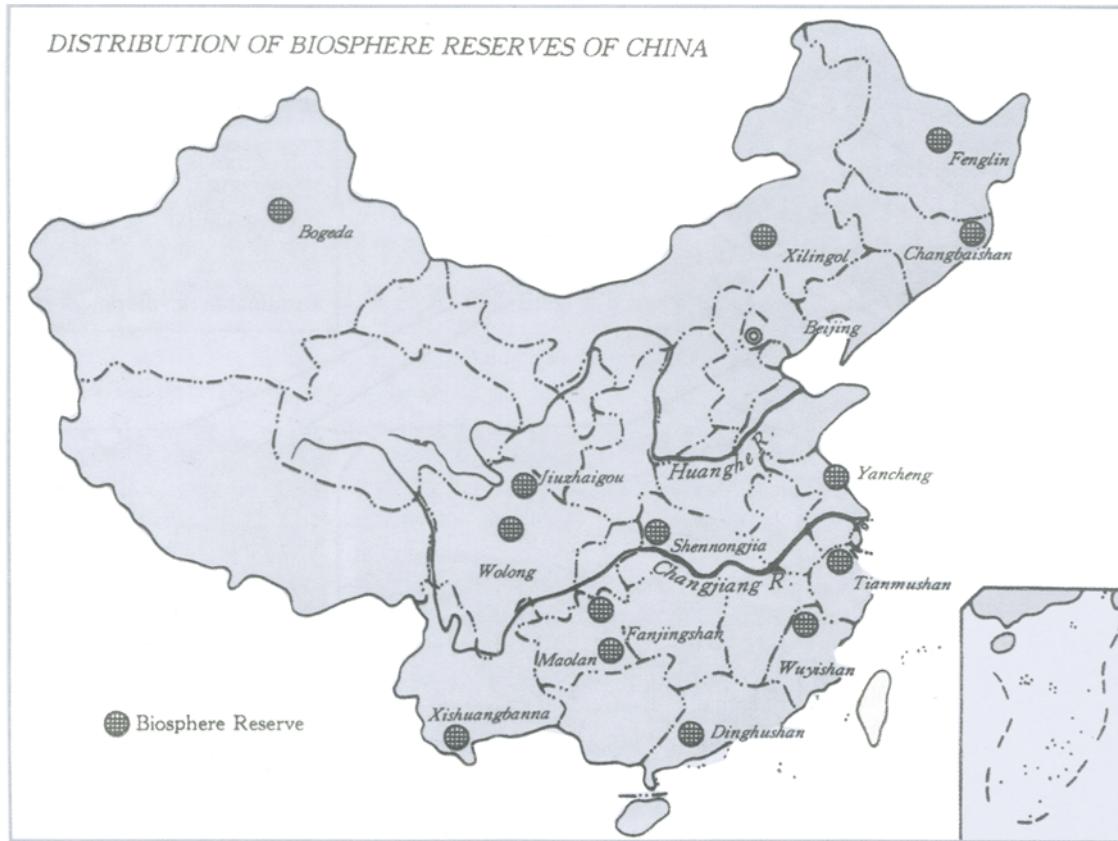


Fig. 2 Distribution of biosphere reserves of China

Fanjing Mountain is the only place in the world where Guizhou golden monkey lives. It is a relic of the Quaternary and a real "living fossil", which has been proven by fossils found near the Fanjing Mountain. It only has a population of about 800. Being a primate with such a small population, Guizhou golden monkey has never been exhibited in any zoo in the world except in the Beijing Zoo. Naturally, Fanjing Mountain Reserve became the only re-

search center for Guizhou golden monkey. Through systematic studies on this animal, the research workers of the reserve have gained a basic knowledge of its pathology and physiology, which is the premise for the protection and management of the monkey and their primate relatives. Now the reserve has for the first time artificially bred four Guizhou Golden Monkeys.

Study area

Fanjing Mountain Biosphere Reserve is in the center of the subtropics of China. It is located between $27^{\circ}46'50''N$ and $28^{\circ}1'30''N$, $108^{\circ}35'55''E$ and $108^{\circ}48'30''E$. The annual average temperature is $6\text{--}17^{\circ}\text{C}$, mean January temperature $-3.1\text{--}5.1^{\circ}\text{C}$, and the mean July temperature is $15\text{--}27^{\circ}\text{C}$. The climate is characterized by the typically mid-subtropical mountain moist monsoon climate. The protected area in the reserve is 27 km long and 21 km wide, covering a total land area of 38743 hm^2 . The major objectives of the Reserve are to protect the *Phinopithecus roxellanae brelichi*, *Panthera tigris amoyensis*, *Neofelis nebulosa*, *Symaticus ellioti* and *Andrias davidianus*, and the Chinese dove tree (*Davidia involucrata*) community is particularly precious, and other first or second rate species of national protection including *Cercidiphyllum japonicum*, *Abies fanjingshanensis* and *Larix mastersiana*, etc., as well as their habitats. The reserve is a typical forest ecosystem and is the first reserve for research on forest ecosystems in China. Fanjing Mountain is the main peak of the Wuling mountain range, towering aloft among 20 surrounding peaks. It is the area where east Yunnan—Guizhou Plateau and west Hunan Hills meet. Fanjing Mountain is dominated by the southeast monsoon, and is the best preserved forest ecosystems in the moist area of China's east subtropics. Distributed from the foot to the top are: evergreen broadleaf forest, evergreen and deciduous broadleaf mixed forest, deciduous broadleaf forest, alpine coniferous forest and shrubby meadow. The area is warm and wet throughout geological changes. As a result, great numbers of the Tertiary and the Quaternary relic species have been preserved, among them over 2000 vascular plants. There are 19 animal species listed as State's priorities for protection.

Results

Habitat distribution

The habitats used by the Guizhou golden monkey included not only the original forest ecosystem, but also man made types. Our study found that Guizhou golden monkey is distributed mainly on 5 types of habitat. The characteristics of habitats are listed below and their distribution is shown in Figure 3. Table 1 gives the characteristics of the main habitat types.

The most suitable habitats

The evergreen and deciduous broadleaf mixed forest is the most suitable habitat area for Guizhou golden monkey. In this type of habitat area, the greatest population has 98 individuals. The altitude of this area is located between 1500 m and 1700 m. The annual average temperature is $8\text{--}15^{\circ}\text{C}$, the lowest temperature of the mean January is $2.5\text{--}4.0^{\circ}\text{C}$, and the highest temperature of the mean July is $17\text{--}25^{\circ}\text{C}$. This habitat's characteristics of vegetation in-

clude three communities.

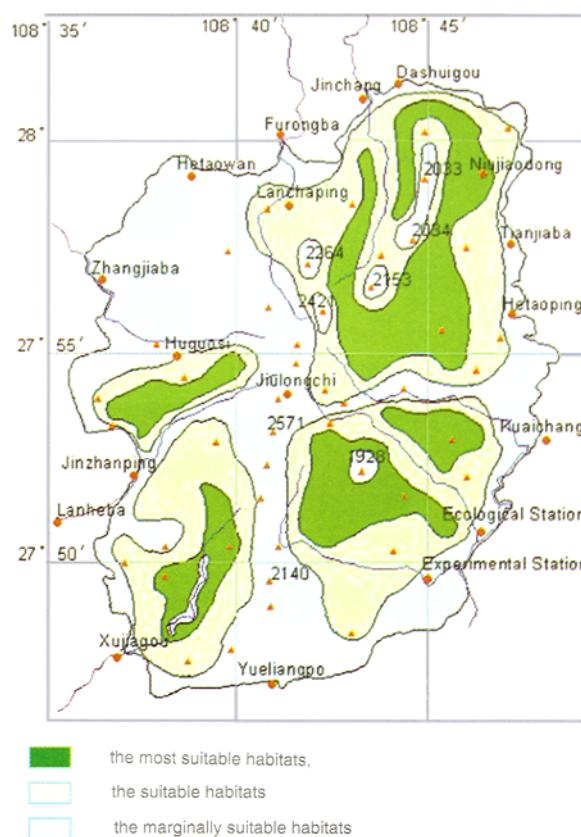


Fig. 3 Habitat selection of *Phinopithecus roxellanae brelichi* in Fanjing Mountain Biosphere Reserve. The most suitable habitats, the suitable habitats and the marginally suitable habitats are divided according to suitable vegetation type and altitude.

(1) *Fagus spp.* and *Sinarundinaria cbungii* community is composed of *Fagus spp.* and *Sinarundinaria cbungii*, which is the most suitable habitat for Guizhou golden monkey. In the middle-high mountain areas, the dominant vegetation is the evergreen and deciduous broadleaf mixed forest, mainly including *Fagus spp.*, *Cyclobalanopsis glauca*, *Cyclobalanopsis gracilis*, *Cyclobalanopsis stewardiana*, *Cyclobalanopsis oxyodon*, and *Sinarundinaria cbungii*, etc. The community is one of the most important types of original mountain forests in the southwestern region of China. This forest type is a climax vegetation type on mountain soil. The abundance and species diversity on this type of land are numerous.

(2) *Quercus englriana* and *Sinarundinaria cbungii* community is composed of *Quercus englriana*, *Sinarundinaria cbungii*, *Davidia involucrata*, *Cercidiphyllum japonicum*, *Abies farjingshanensis*, and *Larix mastersiana* as dominant trees. There are 10 animal species listed as State's priorities for protection, e.g., Guizhou golden monkey (*Phinopithecus roxellanae brelichi*), South China tiger (*Panthera tigris amoyensis*), Clouded Leopard (*Neofelis nebulosa*) to be distributed in this community. The community is a climax vegetation type in the community succes-

sion of mountain forest vegetation. The litter and nutritive elements content of the soil is high. *Quercus englariana* and *Sinarundinaria cbungii* community is highly suitable habitat area for Guizhou golden monkey and the alimental plants are listed in Table 2.

(3) *Cyclobalanopsis stewardiana* and *Sinarundinaria cbungii* community, which compromises deciduous broad-

leaf trees, including *Cyclobalanopsis stewardiana*, *C. oxyodon*, *Acer* spp., the most alimental plants for Guizhou golden monkey (Table 2), is an intermediate stage in the community succession of mountain forest vegetation. Its succession climax community is *Quercus* spp. and *Sinarundinaria* spp. community.

Table 1. The characteristics of the main habitat types for *Phinopithecus roxellanae brelichi*

Type of habitat	Type of Community	Ecological characteristics				
		Diversity of species	Altitude (m)	Annual average temperature /°C	The highest temperature /°C	The lowest temperature /°C
The most suitable habitats	The evergreen and deciduous broadleaf mixed forest	128	1500-1700	8~15	-2.5~4.0	17~25
The suitable habitats	The evergreen and deciduous broadleaf mixed forest	102	1420-1500 1700-1780	6~18	-3.0~4.5	15~27
The marginally suitable habitats	Deciduous broadleaf species; Needle-broadleaf mixed forest	64	1300-1420 1780-1900	5~20	-2.5~5.0	13~28

Table 2. The alimental plants for *Phinopithecus roxellanae brelichi*

Alimental plants species	Parts of aliment	Favorite degree	Alimental plants species	The parts of aliment	Favorite degree
<i>Cyclobalanopsis glauca</i>	Leaf, bud	+	<i>Mangnolia</i> spp.	Bud	+++
<i>Castanopsis cbunii</i>	Leaf	+	<i>Malus</i> spp.	Fruit	+
<i>Cyclobalanopsis multinervis</i>	Tender leaf	+	<i>Prunus serrulata</i>	Tender leaf, fruit	+++
<i>Ternstroemia gymnanthera</i>	Leaf	+	<i>Pyrus</i> spp.	Tender leaf	+
<i>Davidia involucrata</i>	Leaf	++	<i>Sorbus folgneri</i>	Tender leaf	++
<i>Scbeffera biomerulata</i>	Tender leaf	+	<i>Sorbus</i> spp.	Leaf	++
<i>Cornus controversa</i>	Leaf, flower	++	<i>Euonymus</i> spp.	Leaf	+++
<i>Viburnum betulifolium</i>	Leaf	+	<i>Acer davidii</i>	Leaf, bud	+++
<i>Mabonia fortunei</i>	Tender leaf	+++	<i>Acer flabellatum</i>	Leaf, bud	+++
<i>Cyclobalanopsis oxyodon</i>	Tender leaf	+	<i>Acer francbetii</i>	Leaf, bud	+++
<i>Cyclobalanopsis stewardiana</i>	Tender flower	++	<i>Acer</i> spp.	Leaf, bud	+++
<i>Carpinus pubescens</i>	Tender leaf	+	<i>Scbima argentea</i>	Leaf, bud	+++
<i>Magnolia officinalis</i>	Bud	+++	<i>Scbeffera</i> spp.	Tender leaf	+
<i>Symplocos</i> spp.	Leaf, bud, cortex	+++	<i>Theaceae</i>	Leaf, bud, cortex	+++
<i>Photinia</i> spp.	Bud, cortex, leaf	++	<i>Symplocaceae</i>	Bud, cortex, leaf	+++
<i>Kadsura longepedunculata</i>	Fruit, bud, cortex, leaf	+++	<i>Celastraceae</i>	Fruit, flower, leaf	+++
<i>Kadsura coccinea</i>	Flower, bud, cortex, leaf	+++	<i>Rosaceae</i>	Fruit, bud, cortex, leaf	+++
<i>Euonymus</i> spp.	Fruit, flower, bud, cortex, leaf	+++	<i>Fagaceae</i>	Fruit, flower, bud, cortex, leaf	+++
<i>Fagus lucida</i>	Fruit, flower, bud, cortex, leaf	+++	<i>Cyclocarya paliurus</i>	Fruit, flower, bud, cortex, leaf	+++
<i>Cotoneaster divaricatus</i>	Fruit, flower, bud, cortex, leaf	+++	<i>Stranvaesix davidiana</i>	Fruit, flower, bud, cortex, leaf	+++
<i>Actinidia</i> spp.	Fruit, flower, bud, cortex, leaf	+++	<i>Conus kousa</i>	Fruit, flower, bud, cortex, leaf	+++
<i>Akebia quinata</i>	Fruit, flower, bud, cortex, leaf	+++	<i>Rubus</i> spp.	Fruit, flower, bud, cortex, leaf	+++

The “+++” like to eat the alimental plant, the “++” relatively like to eat the alimental plant, the “+” is the alimental plant in the food.

Suitable habitats

Evergreen and deciduous broadleaf mixed forest which is composed of environmental factors such as vegetation and soil is a suitable habitat area for Guizhou golden monkey. In the suitable habitat area, the greatest population has 38 individuals. The altitude of this area (suitable habitats) is located between 1420-1500 m and 1700-1780 m. The annual average temperature is 6-18 °C, the lowest temperature of the mean January is -3.0-4.5 °C, and the highest

temperature of the mean July is 15-27 °C. The vegetation of this habitat compromises two forest types.

(1) *Cyclobalanopsis gracilis* forest is the most suitable habitat for Guizhou golden monkey. In middle-high mountain areas, the dominant vegetation is the evergreen and deciduous broadleaf mixed forest, mainly including *Cyclobalanopsis glauca*, *Cyclobalanopsis gracilis*, *Cyclobalanopsis stewardiana*, *Cyclobalanopsis oxyodon*, and *Acer* spp., *Sorbus* spp., *Symplocos* spp. The community is one of the important forest types of the original

mountain forest in Fanjing Mountain Reserve. This forest type is a climax vegetation type on mountain soil. The abundance and species diversity on this type of land are comparatively rich. These areas are the source of food and regions of action for Guizhou golden monkey relatively puny population.

(2) *Cyclobalanopsis glauca* forest whose dominant trees include *Cyclobalanopsis glauca*, *Davidia involucrata*, *Larix mastersiana*, etc., is a climax vegetation type in the community succession of mountain forest vegetation. Multi broadleaf trees, higher crown density, deep litter layer and preferable condition of soil and water in the forest provided good environment for Guizhou golden monkey to breed.

Marginally suitable habitats

The marginally suitable habitats for Guizhou golden monkey are distributed at the altitudes in range of 1300-1420 m and 1780-1900 m. There annual average temperature is 5-20 °C, the lowest temperature of the mean January is -2.5-5.0 °C, and the highest temperature of the mean July is 13-28 °C. The region is integrant to Guizhou golden monkey's existence. The Guizhou golden monkey move about on upper mountain forest lands in the sweltering summer and transfer to the lower mountain forest lands in the cold winter. In these areas, the greatest population has 18 individuals. At the altitude of 1300-1420m, the marginally habitat's vegetation mainly comprises evergreen broadleaf species, which is the main food source for Guizhou golden monkey in the winter. At the altitude of 1780-1900 m, the marginally habitat's vegetation mainly

comprises deciduous broadleaf species and needle-broadleaf mixed forest species, which are parts of a food source for Guizhou golden monkey in early spring and late autumn.

Habitat selection

The numbers of Guizhou golden monkey population in different habitats and different plant communities are listed in Table 3. Habitat selection was analyzed by comparing expected and observed habitat lived by Guizhou golden monkey. In Table 3, the relative habitat lived by the *Phinopithecus roxellanae brelichi* population is compared with the relative habitat availability within the study area. Fanjing Mountain Biosphere Reserve has at least five Guizhou golden monkey communities, which are distributed in the evergreen and deciduous broadleaf mixed forest. The population in the highly suitable habitat at an aptitude of 1500-1700m accounts for 50%-83% of the total population and the population in the suitable habitat at the altitudes of 1420-1500 m and 1700-1780 m accounts 20%-50%. Only in winter, early spring and late autumn, Guizhou golden monkey takes actions in the marginally suitable habitat at the altitudes of 1300-1420 m and 1780-1900 m, moreover, its population is small, only about 11-14 individuals (Fig.3). At the same time, the area at an altitude of 1420-1780 m is the most suitable habitat for Guizhou golden monkey in winter, early spring and late autumn. In these seasons, the Guizhou golden monkey has a large activity space, but in the scorching, its activity space is small, because food is ample at this time.

Table 3 Habitat selection by *Phinopithecus roxellanae brelichi*

Observed time	Number of <i>Phinopithecus roxellanae brelichi</i>					
	Highly suitable habitat		Suitable habitat		Marginally suitable habitat	
	Population	Individual number	Population	Individual number	Population	Individual number
Mar. 1997	3	36	1	26	1	12
July 1997	4	284	1	98	0	0
Oct. 1997	3	84	2	36	0	0
Jan. 1997	2	28	3	38	0	0
Mar. 1998	3	80	1	28	1	12
July. 1998	5	360	0	0	0	0
Oct. 1998	4	68	1	24	0	0
Jan. 1998	3	43	1	18	1	12

Guizhou golden monkey in the Fanjing Mountain Biosphere Reserve is divided into three areas and five groups according to the geographic area (Fig.3):

- Songtao County area, including Yangaoping group, about 430 individuals;
- Jiangkou County area, about 180 individuals, including Zhenggouhe group (about 30 individuals), Fenghuangshan group (about 90 individuals), and Jinzhaping group;
- Yinjiang County area, including Doupengshan group, about 180 individuals.

Discussion

Guizhou golden monkey likes group life. Because the distributed area is big, we can only observe a part of a group. The main activity of the monkey is in the crown layer of the tall arbors. Guizhou golden monkey likes eating green leaf. Its movement scope changes with different seasons as large in winter, middling in spring and autumn, and small in summer.

The vegetation type of the optimal living habitat for Guizhou golden monkey is evergreen and deciduous broadleaf mixed forest. The area that is located at the altitude of 1500-1700 m is the most suitable habitats, where the annual average temperature is 8-15°C, the lowest temperature of the mean January is -2.5-4.0°C, and the highest temperature of the mean July is 17-25°C. The characteristic vegetation in this habitat include three communities: (1) *Fagus* spp. and *Sinarundinaria cbungii* community; (2) *Quercus englariana* and *Sinarundinaria cbungii* community, (3) *Cyclobalanopsis stewardiana* and *Sinarundinaria cbungii* community. The area at altitudes between 1420 m and 1500 m, and 1700 m and 1780 m, is the suitable habitat area for Guizhou Golden Monkey, where the annual average temperature is 6-18 °C, the lowest temperature of the mean January is -3.0-4.5°C, and the highest temperature of the mean July is 15-27°C. The characteristic vegetation in this habitat includes two forest types: *Cyclobalanopsis gracilis* forest and *Cyclobalanopsis glauca* forest.

Although many studies had been carried out on the biosphere reserve (Donovan 1987; Herr 1993; Duncan 1995; Fielding 1995; Lavers 1996; Velazquez 1996; Walsh 1996), it is rare to study the habitat of rare and endangered species by combining the characteristic of vegetation community with environmental factors. Our study revealed that the vegetation community and environmental factors are the key factors in determining the living and distribution of rare and endangered animals.

The temperature factor and food factor in a habitat are critical factors in determining the activity scope of Guizhou golden monkey. In the cold season, as there is little food in the optimal habitat, its activity scope moves downward. In the hot season, to avoid high temperature, the activity scope of Guizhou golden monkey moves upward.

The population of Guizhou golden monkey community is between *Rhinopithecus rexellanae rexellanae* Milne Edward community and *Rhinopithecus rexellanae bieti* Milne Edward community, but Guizhou golden monkey distributes most narrowly among the three Golden Monkeys. It requires a rigor habitat. The main protection measure for protecting Guizhou golden monkey is to protect the evergreen and deciduous broadleaf mixed forest in Fanjing Mountain Area, for this forest provides Guizhou golden monkey with an optimal habitat.

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